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Survival Time in Sheep Affected by Sheep Pox and Enterotoxaemia

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Abstract: To assess the factors that influence the survival time of sheep affected by sheep pox or enterotoxaemia, 150 sheep farms affected by sheep pox (108) and enterotoxaemia (42) were selected through multistage random sampling technique from the purposively selected Dharmapuri district of Tamil Nadu. Relevant data were collected for the period of two years (2000-01 and 2001-02). The data so collected were used to fit Cox hazard functional models separately for each disease. One unit increase in breed and veterinary care indicators in sheep pox affected flock would increase the hazard rate by 10.49 and 15.61%, respectively. Similarly, one unit increase in age and vaccination would decrease hazard rate by 66.40 and 67.23%, respectively. The relative risk for the non-provision of veterinary care indicated that the risk of dying was 4.16 times higher for an animal provided with no veterinary care, compared to the one, which received veterinary care. One unit increase in breed and veterinary care indicators in enterotoxaemia affected flock would increase the hazard rate by 78.00 and 2.43%, respectively. Similarly, a unit increase in deworming would decrease the hazard rate by 36.01%. The relative risk for the non-provision of veterinary care indicated that the estimated risk of dying is 3.02 times higher for an animal provided with no veterinary care, compared to the one, which received veterinary care.

Key words: Sheep pox, enterotoxaemia, survival time

INTRODUCTION

The profitability of sheep farms is often shattered due to the occurrence of diseases, especially that of infectious. Among those infectious diseases affecting sheep, sheep pox and enterotoxaemia are considered to be the most important ones economically. Singh *et al.*[1], Kitching[2], Mullick[3] and Carn[4] had all reported heavy economic losses in sheep pox outbreaks due to either mortality, abortions or loss of market value of affected animals, while Narayan[5], Harbola and Kumar[6] and Arya and Bhatia[7] claimed mortality of almost 100% in enterotoxaemia affected sheep. With such observations, it is essential to estimate the time period for which the sheep affected with either of the diseases would survive, as time of death due to the disease or the survival time would help to assess the veterinary, labour and other related expenses that might accrue in terms of disease losses. Hence, this study was undertaken to assess the factors that influence the survival time of sheep affected by sheep pox or enterotoxaemia.

MATERIALS AND METHODS

Dharmapuri district of Tamil Nadu was purposively selected for the present study, as this district was topping the State in terms of sheep population and also frequently encountering frequent outbreaks of sheep pox and enterotoxaemia. For the study, 150 sheep farms affected by sheep pox (108) and enterotoxaemia were selected through multistage random sampling technique. Out of 18 blocks available in this district, 6 blocks viz., Hosur, Thally, Shoolagiri, Kaveripattinam, Morappur and Pennagaram were selected randomly. Five villages were selected from each block and five sheep farmers from each village. Relevant data were collected for the period of two years (2000-01 and 2001-02) by personal interview method, using pretested interview schedule. The data collected include information on age, breed and sex of diseased animals, flock size, system of rearing and season of disease outbreak. The data so collected were used to fit Cox hazard functional models separately for each disease.

Cox hazard functional model-the conceptual framework: The survival time after diagnosis of a disease depends on a few predictor variables such as the severity of the disease, age of the animals affected, treatment method, etc. Multiple linear regression technique cannot be used for analysis of time-to-event data, since there is no way to handle censored observations. Censored cases are those for which the event (death) has not occurred. This cannot be ignored but must be incorporated into analysis. A

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special type of regression model namely the Cox regression model can be used to analyse the data that contains censored observations. The model is

$$h(t) = [h_o(t)]\, e^{(b1\,X1 + b2\,X2 + . + bn\,Xn)}$$

where X_1 to X_p are the covariates.

From the model we can see that for any values of the independent variables, the proportion of getting into hazard at time t depends on two quantities. The first, designated as $h_o(t)$ in the equation is called the base line hazard function. The base line hazard function is similar to constant term in multiple regression. That is, it is the reference value that is increased or decreased depending on the values of the independent variables and their relationship with the dependent variable. The base line hazard function depends only on time. The second part of the equation, that is $e^{(bixi)}$ in the model, depends not on time but on the values of the independent variables (covariates) like X_1 to X_n and on the regression coefficients b_i.

To examine the effects of independent variables on hazard, we can calculate a Cox regression model with death time as the dependent variable and the independent variables as the covariates. One important statistic that is calculated here is the Wald statistic, which is the ratio of the coefficient to its standard error. For large samples, Wald statistic has a chi-square distribution. The degrees of freedom associated with this statistic are 1. The letter R measures the partial correlation of each independent variable with the dependent variable. R ranges from -1 to +1. R is 0 if the Wald statistic is less than twice the degrees of freedom for the variable. Otherwise R is defined as:

$$R = \pm\sqrt{\frac{\text{Wald statistic} - (2 \times df)}{-2 \times \log \text{likelihood for initial model}}}$$

RESULTS AND DISCUSSION

Prevalence of sheep pox: Table 1 presents an overall view of the prevalence of sheep pox and enterotoxaemia during the study period (2000-01 and 2001-02). The number of sheep affected by sheep pox was 124 (22.30%) and 914 (29.94%) in 2000-01 and 2001-02, respectively, with an overall prevalence of 28.76% during the study period. The number of sheep affected by enterotoxaemia was 72 (14.55%) and 85 (9.35%) in 2000-01 and 2001-02, respectively, with an overall prevalence of 11.18% during the study period.

Mortality and case fatality rates in sheep pox and enterotoxaemia: The details of mortality and case fatality rates in sheep pox and enterotoxaemia affected animals are presented in Table 2. The mortality rate in sheep pox affected animals was 22.19%. Belwal *et al*.[8] reported 19% mortality in sheep pox affected animals, while Garner *et al*.[9] observed an average mortality rate of 49.5%. The case fatality rate in sheep pox was found to be 77.17%.

The mortality rate in enterotoxaemia was found to be 11.18%, which is in accordance with the results of Richards *et al*.[10] who reported that the incidence was around 10%. It needs emphasis that though the prevalence was relatively low in enterotoxaemia, a cent percent case fatality rate was observed, implying that once affected none survives the disease, as found by Narayan[5].

Cox hazard functional model for sheep pox: The results of Cox hazard functional model fitted for sheep pox are presented in Table 3. While B column presents the coefficients estimated, the standard errors of the coefficients are shown in the next column. The square of the ratio of the coefficient to its standard error is given in the column labelled Wald stat. For large samples, the Wald statistic has a chi-square distribution. The degrees of freedom associated with the statistic are 1. From column Sig, it can be seen that the coefficients for age, breed, vaccination and veterinary care are significantly different from 0, while the coefficients for others are not. The column R gives the partial correlation of each independent variable with the dependent variable, which can range from -1 to +1.

The column Exp(B) indicates the percentage change in the hazard rate for a unit increase in the covariate. For example, a unit increase in breed and veterinary care indicators would increase the hazard rate by 10.49 and 15.61%, respectively, since the ratio of the hazard rates are 1.1049 and 4.1561. Similarly, a unit increase in age and vaccination would decrease hazard rate by 66.40 and 67.23%, respectively.

Further, for the dichotomous significant variables (age, vaccination and veterinary care), the Exp(B) value is called as the Relative Risk (RR) associated with the variable. If RR is 1, the variable concerned does not influence survival. But if RR is less than one, a positive value for the variable is associated with the increased survival, since the hazard rate is decreased. From the table, the RR for the non-provision of veterinary care is 4.16, which indicates that the estimated risk of dying is 4.16 times higher for an animal provided with no veterinary care, compared to the one which received veterinary care.

Cox hazard functional model enterotoxaemia: The results of Cox hazard functional model fitted for enterotoxaemia

Table 1: Prevalence of sheep pox and enterotoxaemia in the study area (in numbers)

	Sheep pox		Enterotoxaemia	
Year	No. of sheep studied	No. of sheep affected	No. of sheep studied	No. of sheep affected
2000-01	556	124 (22.30)	495	72 (14.55)
2001-02	3053	914 (29.94)	909	85 (9.35)
Overall	3609	1038 (28.76)	1404	157 (11.18)

(Figures in parentheses indicate percentages to the respective totals)

Table 2: Mortality and case fatality rates in sheep pox and enterotoxaemia

	Mortality rate		Case fatality rate	
Farm size	No. of sheep exposed to the disease	No. of sheep died	No. of sheep affected by the disease	No. of sheep died
Sheep pox	3609	801 (22.19)	1038	801 (77.17)
Enterotoxaemia	1404	157 (11.18)	157	157 (100.00)

(Figures in parentheses indicate percentages to the respective totals)

Table 3: Results of cox hazard functional model fitted for sheep pox

Variable	B	SE	Wald stat	df	Sig	R	Exp (B)
Age (1-Adult, 0-young)	-0.4095	0.1004	16.6448	1	0.0000	-0.0394	0.6640
Sex (0-Male, 1-Female)	0.0319	0.1077	0.0877	1	0.7671	0.0000	1.0324
Breed (3-Trichy Black, 2-Mandya, 1-Mecheri)	0.0997	0.0456	4.7927	1	0.0286	0.0172	1.1049
Season (4-Winter, 3-NE monsoon, 2-Summer, 1-SW monsoon)	0.0972	0.0796	1.4914	1	0.2220	0.0000	1.1020
Vaccination (1-Not vaccinated, 0-Vaccinated)	-0.3971	0.1013	15.3480	1	0.0001	-0.0376	0.6723
Veterinary care (1-Not attended, 0-Attended)	1.4246	0.1037	188.874	1	0.0000	0.1407	4.1561

Table 4: Results of cox hazard functional model fitted for enterotoxaemia

Variable	B	SE	Wald stat	df	Sig	R	Exp (B)
Age (1-young, 0-Adult)	-0.1183	0.5269	0.0504	1	0.8224	0.0000	0.8885
Sex (1-Male, 0-Female)	-0.0431	0.2068	0.0435	1	0.8348	0.0000	0.9578
Breed (3-Mecheri, 2-Trichy Black, 1-Mandya)	0.5766	0.2974	3.7581	1	0.0526	0.0359	1.7800
Season (4-SW monsoon, 3-NE monsoon, 2-Winter, 1-Summer)	0.0070	0.5018	0.0002	1	0.9888	0.0000	1.0071
Deworming (1-Not done, 0-Done)	-1.0213	0.4721	4.6796	1	0.0305	-0.0443	0.3601
Veterinary care (1-Not attended, 0-Attended)	1.1067	0.2111	27.4783	1	0.000	0.1365	3.0243

are presented in Table 4. From column Sig, it can be seen that the coefficients for breed, deworming and veterinary care are significantly different from 0, while the coefficients for others are not. The column Exp(B) indicates that a unit increase in breed and veterinary care indicators would increase the hazard rate by 78.00 and 2.43%, respectively, since the ratio of the hazard rates are 1.7800 and 3.0243. Similarly, a unit increase in deworming would decrease hazard rate by 36.01%. Further, for the dichotomous significant variable-veterinary care, the Exp(B) value is called as the relative risk associated with the variable. It can be seen that the relative risk for the non-provision of veterinary care is 3.02, which indicates that the estimated risk of dying is 3.02 times higher for an animal provided with no veterinary care, compared to the one which received veterinary care.

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